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1. Your reference	ans.2834.uk
2. Patent application number *(The Patent Office will fill in this part)*	0307521.5 - 1 APR 2003
3. Full name, address and postcode of the or of each applicant *(underline all surnames)*	Specialised Petroleum Services Group Limite Wellbore Completion Services Arnhall Business Park Westhill ABERDEEN AB32 6TQ
Patents ADP number *(if you know it)*	8460784001
If the applicant is a corporate body, give the country/state of its incorporation	United Kingdom
4. Title of the invention	Downhole Tool
5. Name of your agent *(if you have one)* "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	Kennedys Patent Agency Limited Queens House, Floor 5 29 St Vincent Place GLASGOW G1 2DT
Patents ADP number *(if you know it)*	08058240002

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number	Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:* *a) any applicant named in part 3 is not an inventor, or* *b) there is an inventor who is not named as an applicant, or* *c) any named applicant is a corporate body.* *See note (d))*	Yes

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Continuation sheets of this form	--
Description	13
Claim(s)	--
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Priority documents	--
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Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	--
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11. I/We request the grant of a patent on the basis of this application.

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12. Name and daytime telephone number of person to contact in the United Kingdom David Kennedy - 0141 226 6826

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Downhole Tool

The present invention relates to apparatus and a method for circulating fluid in a borehole.

It is common practice to install liners within a borehole which has been drilled. After installation of the liners it is generally necessary to clean out the inside of the liner to wash away any debris or other contaminants.

Generally, the liner is in the form of a cylindrical tube which has a relatively small internal diameter compared with the diameter of casing lining the borehole immediately above the liner. To effectively clean out the inside of the liner, high flow velocities are generally required to create turbulence to aid the cleaning out process. Generally, the clean out procedure is carried out by first passing cleaning liquid through the work string inserted into the liner, to exit from the work string at the lower end of the liner at a high flow rate so that the cleaning fluid flows turbulently up the annulus between the inside of the liner and the outside of the work string and then into the casing above the

liner.

Generally, the work string is made up of a number of lengths of drill pipe, or other tubulars, threadedly connected together to form the work string, which may also be referred to as the drill string.

However, because of the difference in volume between the liner and the casing above the liner, after the cleaning fluid passes the top of the liner and enters the relatively large volume of the casing, the flow velocity of the cleaning fluid in the casing above the liner is greatly reduced and any cleaning action becomes negligible.

Hence, it is generally necessary after passing cleaning fluid through the liner to then pass further cleaning fluid from the work string into the casing at a location above or adjacent the top edge of the liner, so that a high flow rate and hence turbulence of the cleaning fluid can be obtained in the casing. Therefore, it is generally necessary to have some device at or adjacent to the top end of the liner which can be operated downhole to either circulate fluid through the length of the work string to the lower end of the liner or which can direct cleaning fluid at high flow rates out of the work string onto an inner surface of a casing or liner.

Circulation tools have thus been developed to redirect fluid flow through the work string radially outward of the tool, to impact the inner wall of the casing or liner. By making the radial exit ports small, fluid velocity is increased at these locations, thus improving

cleaning. Various methods have also been developed to control the exit of fluid from the radial ports and provide a tool with selectable operation.

One such circulation tool is that disclosed in US 4,889,199. This tool comprises tubular casing means for mounting in a drill string; first outlet means in said casing means for discharging fluid from said casing means; sleeve means slidably mounted in said casing means; spring means in said casing means biasing said sleeve means to a closed position in which said sleeve means closes said first outlet means; second outlet means in said sleeve means for discharging fluid from said sleeve means when said first and second outlet means are aligned; a ball, retainer means in said sleeve means for releasably retaining said ball for preventing flow of drilling fluid through said sleeve means and causing said sleeve means to move relative to said casing means into an open position in which said first and second outlet means are aligned to discharge fluid through said casing means, a second ball for blocking said second outlet means so that pressure on said first and second balls increases sufficiently to drive said first ball through said sleeve means for restoring the normal flow of drilling fluid through said sleeve means and for allowing the return of said sleeve means to said closed position.

A disadvantage of this tool is that it requires both a deformable ball and a smaller metal ball to operate. Care must then be taken to ensure the balls are dropped in the correct order. The smaller metal ball must lodge in the second, radial, outlet in order to stop flow and thus the tool is restricted to having a single radial port. This

limits the amount of cleaning which can be performed. Yet further is a disadvantage in that when the tool is in the open configuration, fluid flow is against the seals between the sleeve and casing causing increased wear and potential failure.

It is thus an object of the present invention to provide a downhole tool for circulating fluid in a borehole which can be operated using a uniform drop ball.

It is a further object of at least one embodiment of the present invention to provide a downhole tool for circulating fluid in a borehole which includes a plurality of radial ports and is operated by a drop ball.

According to a first aspect of the present invention there is provided a downhole tool for circulating fluid in a borehole, the tool comprising tubular casing means for mounting in a work string; first outlet means in said casing means for discharging fluid from said casing means; sleeve means slidably mounted in said casing means; second outlet means in said sleeve means for discharging fluid from said sleeve means when said first and second outlet means are aligned; engagement means to control relative movement between said sleeve means and said casing means; spring means biasing said sleeve means against said engagement means; a ball; retainer means in said sleeve means for releasably retaining said ball for preventing flow of fluid through said sleeve means and causing said sleeve means to move relative to said casing means as determined by said engagement means.

Preferably the ball is deformable. In this way the ball can be released and the tool re-used in the borehole.

Preferably also the tool includes ball collecting means. The ball collecting means may be an element located in the casing means to prevent passage of the ball through the tool, but allowing passage of fluid through the tool.

Preferably said outlet means are radial ports located substantially perpendicular to a longitudinal axis through the tool. More preferably there are a plurality of said first and said second outlets. Advatageously there are three or more said first and said second outlets. Preferably also said first and said second outlets are spaced equidistantly around the casing means and sleeve means respectively.

Preferably said engagement means comprises at least one index pin located in a profiled groove. Preferably the at least one index pin is located on the casing means and the profiled groove is located on an outer surface of the sleeve means. In this way, an index sleeve is produced with the groove determining the relative position of the sleeve means to the casing means. Advantageously the groove extends circumferentially around the sleeve means, thus the tool can be continuously cycled.

Preferably the retainer means is a ledge or shoulder located on an inner surface of the sleeve means. The ball therefore rests on the shoulder until sufficient pressure builds up to force the ball passed the shoulder.

Preferably also the spring means is located in a chamber created between the sleeve means and the casing means. Advantageously the chamber includes an exhaust port such that fluid can enter and be dispelled from the chamber by relative movement of the sleeve means and the casing means.

According to a second aspect of the present invention there is provided a method of circulating fluid in a borehole, the method comprising the steps:

(a) inserting in a work string a tool comprising a tubular casing including a plurality of first radial outlet ports in which is located a sleeve including a plurality of second radial outlets and an engagement mechanism for moving the sleeve relative to the casing;

(b) running the work string and tool into a borehole, with the sleeve in a first position relative to the casing wherein the first and second radial outlets are misaligned and fluid flow is through the work string;

(c) dropping a ball into the work string such that the ball lands on the sleeve and forces the sleeve into a second position relative to the casing wherein the first and second radial outlets are misaligned and fluid flow is through the work string; and

(d) increasing pressure behind the ball to deform the ball and force it through the sleeve, the releasing pressure allowing the sleeve to move to a third position relative to the casing wherein the first and second radial outlets are aligned and fluid flows through the radial outlets.

Preferably the method further includes the steps of:

(e) dropping a second ball, identical to the first ball, into the work string such that the second ball lands on the sleeve and forces the sleeve into the second position relative to the casing wherein the first and second radial outlets are misaligned and fluid flow is through the work string; and

(f) increasing pressure behind the second ball to deform the second ball and force it through the sleeve, the releasing pressure allowing the sleeve to move to the first position relative to the casing wherein the first and second radial outlets are misaligned and fluid flows through the radial outlets.

With the sleeve and casing back in the first position, the steps (c) to (f) can be repeated any number of times.

Preferably also the method includes the step of catching the dropped balls in the work string.

An embodiment of the present invention will now be described by way of example only with reference to the following Figures, of which:

Figure 1 is a part cross-sectional view of a downhole tool in a first position according to an embodiment of the present invention;

Figure 2 is a part cross-sectional view of the downhole tool of Figure 1 in a second position;

Figure 3 is a part cross-sectional view of the downhole tool of Figure 1 in a third position; and

Figures 4(a)-(c) are schematic illustrations of an index pin positioned in a groove of the tool of Figure 1 for the first, second and third positions respectively.

Reference is initially made to Figure 1 of the drawings which illustrates a downhole tool, generally indicated by reference numeral 10, in accordance with an embodiment of the present invention. Tool 10 includes a cylindrical body 12 having an upper end 14, a lower end 16 and a cylindrical bore 18 running therethrough. The body 12 has a box section 20 located at the upper end 14 and a pin section 22 located at the lower end 16 for connecting the tool 10 in a work string or drill string (not shown).

The body 12 further includes four radial ports 24 located equidistantly around the body 12. The ports 24 are perpendicular to the bore 18.

Located on an inner surface 26 of the body 12 are two opposing ledges 26, 28 used to limit axial movement of a sleeve 30 located within the body 12. Sleeve 30 is sealed against body 12 by o-rings 31a-d.

Sleeve 30 is an annular body which also includes four radial ports 32 located equidistantly around the sleeve 30. The ports 32 are perpendicular to the bore 18. The ports 32 are of a similar size to the ports 24 in the body 12.

A ball seat 34 is located on the sleeve 30 at an upper end 36. The ball seat comprises a conical surface 38 facing the upper end 14 of the tool 10. A throat 40 is provided at a base of the conical surface 38, the throat having a diameter less than the diameter of the bore 42 of the sleeve 30.

Located between the outer surface 44 of the sleeve 30 and the inner surface 46 of the body 12 is a space forming a chamber 48. The upper edge of the chamber is formed from a ledge 50 on the outer surface 44 of the sleeve 30. The lower edge of the chamber 48 is formed from the ledge 28 of the body 12. A strong spring 52 is positioned within the chamber 48 and compressed to bias against the ledge 50 of the sleeve 30. An exhaust port 54 is located through the sleeve 30 at the chamber 48 to allow fluid from the bore 42 to pass in to and out of the chamber 48 as the sleeve 30 is moved relative to the body 12.

Further an engagement mechanism, generally indicated by reference numeral 56, couples the sleeve 30 to the body 12 and controls relative movement there between. Engagement mechanism 56 comprises an index sleeve 58, being a portion of the sleeve 30, and a matching index pin 60 located through the body 12 towards the sleeve 30. Index sleeve 58 includes a profiled groove 62 on the outer surface 44 of the sleeve 30 into which the index pin 60 locates.

Reference is now made to Figure 4 of the drawings which illustrates the groove 62 of the index sleeve 58. The groove 62 extends circumferentially around the sleeve 30 in a continuous path. The groove 62 defines a path having

a substantially zig-zag profile to provided axial movement of the sleeve 30 relative to the body 12. Indeed, spring 52 biases the sleeve 30 against the index pin 60. The path includes an extended longitudinal portion 64 at every second upper apex of the zig-zag. Further a stop 66 is located at the apexes of the zig-zags to encourage the index pin 60 to remain at the apexes and provide a locking function to the tool 10. The stops 66 are in the direction of travel of the pin 60 along the groove 62.

Reference is now made to Figure 2 of the drawings which illustrates the tool 10 of Figure 1, now with a ball 68 located in the bore 42. Like parts to those of Figure 1 have been given the same reference numeral for ease of identification. Ball 68 is sized to rest on surface 38 and be of a deformable material e.g. rubber so that under force it can pass through the throat 40.

Reference is now made to Figure 3 of the drawings which illustrates the tool 10 of Figure 1, now with the ball 68 exiting the sleeve 30 into the bore 18. Like parts to those of Figures 1 and 2 have been given the same reference numeral for ease of identification. Body 12 includes a pin 70 located into the bore 18. Pin 70 is a ball retainer pin which blocks the passage of the ball 68 through the bore 18. Ball 68 will come to rest at the pin 70 and therefore be retrievable with the tool 10. Pin 70 does not prevent the flow of fluid through the bore 18 and from the tool 10 into the work string below. The pin 70 and the space 72 in the bore 18 immediately above it may be considered as a ball catcher.

In use, tool 10 is connected to a work string using the box section 20 and the pin section 22. As shown in Figures 1 and 4(a), the spring 52 biases the sleeve 30 against the index pin 60 such that the pin 60 is located in the base apex of the groove 62. This is referred to as the first position of the tool 10. In this position, sleeve ports 32 are located above body ports 24, thus preventing fluid flow radially through these ports due to their misalignment. All fluid flow is through bores 18,42 of the tool 10. The tool 10 is then run into a bore hole until it reaches a location where cleaning of the bore hole casing or circulation of the fluid through the tool is required.

Drop ball 68 is then released through the bore of the work string from a surface. Ball 68 travels by fluid pressure to the ball seat 36 of the sleeve 30. The ball 68 rests on the conical surface 38 and prevents axial fluid flow through the tool 10. Consequently fluid pressure builds up behind the ball 68 and the sleeve 30, including the ball 68, moves against the bias of the spring 52, to a second position. This position is illustrated in Figure 2 and 4(b). The spring 52 is compressed into a now smaller chamber 48. Fluid has been expelled from the chamber 48 through the exhaust port 54. The index pin 60 is now located at the top of the longitudinal portion 64 of the groove 62. Consequently the sleeve ports 32 have crossed the body ports 24 and are now located below them. Fluid flow is thus still entirely through the bores 18,42.

As pressure increases on the ball 68 it is extruded through the throat 40 by deforming. The ball 68 travels

by fluid pressure until it is stopped by the pin 70 and is held in the space 72. On release of the pressure, spring 52 moves the sleeve 30 against the index pin 60 such that sleeve travels to a third position. The third position is illustrated in Figures 3 and 4(c). Fluid has been drawn into the chamber 48 and this drawing and expelling of fluid provides a hydraulic damping effect on the impact on the pin 60. Index pin 60 is now located in an upper apex of the groove 62 and the ports 24,32 are aligned. In this third position fluid is expelled radially from the tool 10 through the now aligned ports 24,32. The tool 10 is locked in this position by virtue of the stop 66 on the groove 62 which prevents movement of the sleeve 30 for small variations in fluid pressure.

In order to close the ports 24,32, a second ball is dropped from the surface through the work string. The second ball, and indeed any ball subsequent to this, is identical to the first ball 68. The second ball will travel to rest in the ball seat 38. On the build up of fluid pressure behind the ball, sleeve 30 will move downwards against the bias of the spring 52. Consequently the index pin 60 will be relocated into the next longitudinal groove 64 of the groove 62 and thus the tool is returned to the second position. When the ball is extruded through the throat 40, the pin 60 and sleeve 30 will move relatively back to the first position and the ball will come to rest by the first ball 68. Effectively the tool is reset and by dropping further balls the tool 10 can be repeatedly cycled in an open and closed manner as often as desired.

It will be appreciated that although the description refers to relative positions as being 'above' and 'below', the tool of the present invention can equally well be used in horizontal or inclined boreholes and is not restricted to vertical boreholes.

The principal advantage of the present invention is that it provides a downhole tool for circulating fluid in a borehole which can be repeatedly operated by dropping identical balls through the work string. A further advantage is that the tool can have any number of radial ports to increase the flow area if desired compared with the prior art.

Further as the ball seat is located above the ports, the ports are opened with no flow going across the seals. This effectively saves the seals from excessive wear. An additional advantage is in the ability of the index sleeve to lock the circulating ports in position when aligned. Yet further the entry and exit of fluid in the chamber for the spring advantageously reduces the impact on the index pin via the hydraulic damping effect.

Various modifications may be made to the invention herein described without departing from the scope thereof. For example, two or more index pins could be used to provide increased stability to the tool and distribute the load on the pins. Additional radial ports could be located at longitudinal spacings on the tool to provide radial fluid flow across a larger area when the ports are open. The ports may have varying diameters which may provide a nozzle on the outer surface of the body to increase fluid velocity.

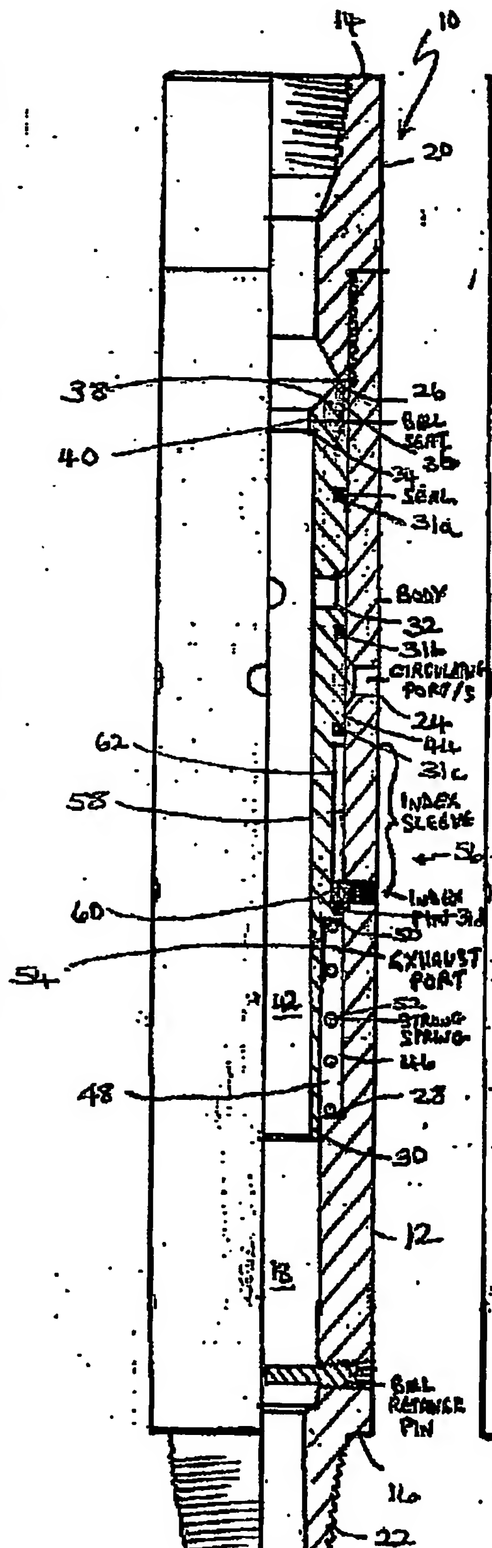

FIG 1

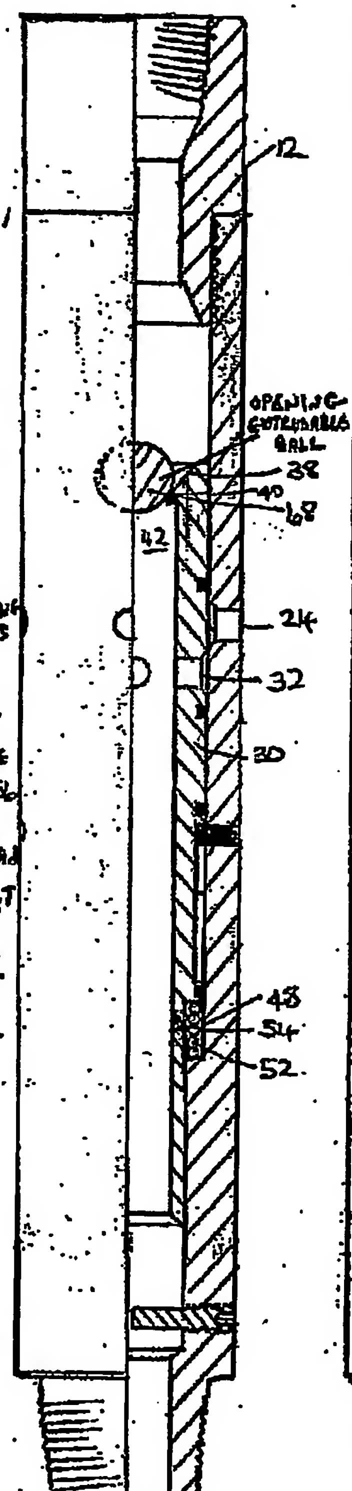

FIG 2

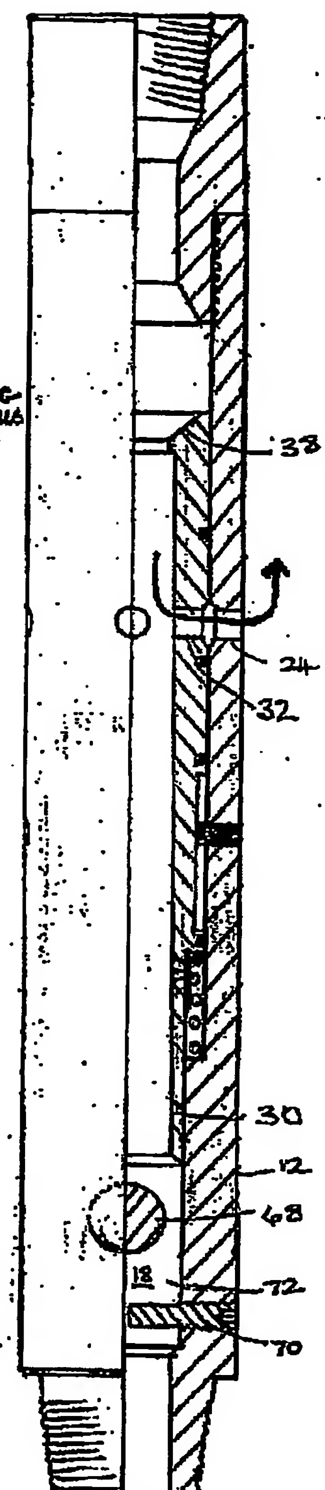

FIG 3

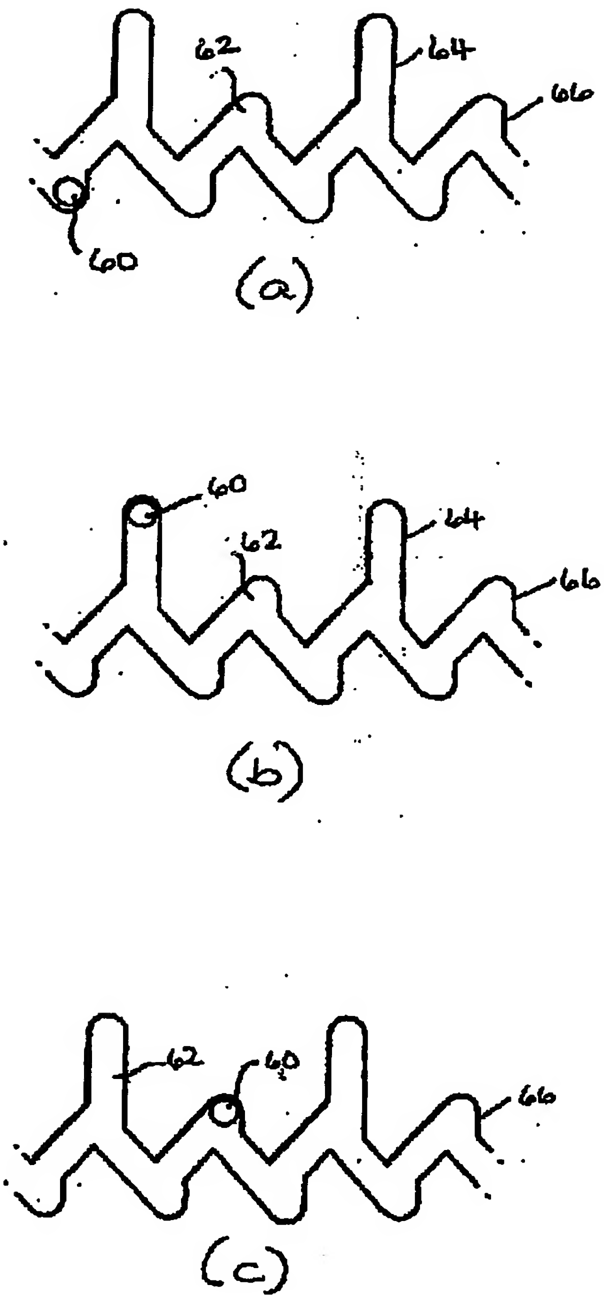

FIG 4